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EXCITATION LIGHT SOURCE BACKUP METHOD FOR OPTICAL FIBER AMPLIFIER

【Claims】

【Claim 1】 An excitation light source backup method for an optical fiber amplifier comprising:

connecting optical coupling and decoupling directional couplers for coupling and decoupling an excitation light to the front and the rear of a rare-earth element doped optical fiber propagating a signal light; connecting, to each one end of the two optical directional couplers, semiconductor lasers for excitation enabling the excitation light to be incident and propagated to the rare-earth element doped optical fiber, and providing a drive circuit for driving either one of the semiconductor lasers via a switch; connecting monitoring photodetector circuits to the other ends of the optical directional couplers; inputting outputs of the monitoring photodetector circuits to a comparator circuit and comparing the outputs with a reference voltage; and controlling the switch using the comparator circuit outputs, so as to drive either of the semiconductor lasers for excitation.

【Claim 2】 An excitation light source backup method for an optical fiber amplifier comprising:

connecting optical coupling and decoupling directional couplers for coupling and decoupling an excitation light to the front and the rear of a rare-earth element doped optical fiber propagating a signal light; connecting, to the two optical directional couplers, semiconductor lasers for excitation enabling the excitation light to be incident and propagated to the rare-earth element doped optical fiber, and providing a drive circuit for driving either one of the semiconductor lasers via a switch; connecting, to the optical directional couplers, photodetector circuits for monitoring the backward light of the excitation light; inputting outputs of the monitoring photodetector circuits to a comparator circuit and comparing the outputs with a reference voltage; and controlling the switch using the comparator circuit outputs, so as to drive either of the semiconductor lasers for excitation.

【Claim 3】 An excitation light source backup method for an optical fiber amplifier comprising:

connecting ring resonators coupling and decoupling an excitation light to the front and the rear of a rare-earth element doped optical fiber propagating a signal light; connecting, to the two ring resonators, semiconductor lasers for excitation enabling the excitation light to be incident and propagated to the rare-earth element doped optical fiber, and providing a drive circuit for driving either one of the semiconductor lasers via a switch;

connecting photodetector circuits to the ring resonators for monitoring a portion of the excitation light; inputting outputs of the monitoring photodetector circuits to a comparator circuit and comparing the outputs with a reference voltage; and controlling the switch using the comparator circuit outputs, so as to drive either of the semiconductor lasers for excitation.

【Claim 4】 An excitation light source backup method for an optical fiber amplifier comprising:

juxtaposing rare-earth element doped optical fibers propagating signal lights; connecting optical coupling and decoupling directional couplers for coupling and decoupling an excitation light, each constituted of an optical Y-branching circuit being disposed in front and rear of the rare-earth element doped optical fibers; connecting, to the two optical Y-branching circuits, semiconductor lasers for excitation enabling the excitation light to be incident and propagated to the rare-earth element doped optical fiber, and providing a drive circuit for driving either one of the semiconductor lasers via a switch; connecting photodetector circuits for monitoring the backward light of the excitation light respectively to the optical Y-branching circuits; inputting outputs of the monitoring photodetector circuits to a comparator circuit and comparing the outputs with a reference voltage; and controlling the switch using the comparator circuit outputs, so as to drive either of the

semiconductor lasers for excitation.

【Detailed description of the invention】

【0001】

【Application field in industry】 The present invention relates to a backup method of an excitation light source supplied to an optical fiber, in which a rare earth element such as Er, Nd, or the like, is doped, in preparation for an emergency, and more particularly an excitation light source backup method enabling excitation by a switched excitation light injected from either the front side or the rear side of the optical fiber.

【0002】

【Prior art】 In recent years, studies are being carried out actively on an optical fiber amplifier having a rare earth element such as Er (erbium), Nd (niobium), Pr (praseodymium), or the like, doped into an optical fiber core, to amplify a signal light by excitation by use of an excitation light having an absorption characteristic which is proper to the doped rare earth element.

【0003】 FIG. 5 shows an exemplary configuration of the conventional optical fiber amplifier.

【0004】 This optical fiber amplifier performs a following function: A signal light in a wavelength band of 1.5 μm is propagated in the core of an Er-doped optical fiber 53, as shown by arrows 50, 51. At the same time, an excitation light having a wavelength of 1.47 μm (or 0,98 μm) is produced by a semiconductor laser 55 driven by a drive circuit 56,

which is supplied from halfway the optical fiber via an optical directional coupler 54, and is propagated in optical fiber 53 also. Thus, an inverted population state is produced, and thereby a function of amplifying the signal light from several hundred times to approximately ten thousand times is obtained. An optical filter provided on the output side has a function of eliminating the excitation light from the semiconductor laser included in the amplified signal light.

【0005】

【Problems to be solved by the invention】 However, in the conventional optical fiber amplifier, the following problems remain to be solved.

【0006】 (1) At present, the lifetime of the semiconductor laser for excitation is quite short. Therefore, the semiconductor laser cannot be used for an optical fiber amplifier in which a desired gain is expected for a long period of time.

【0007】 (2) The optical fiber amplifier can be used for a variety of application, such as booster amplifier, pre-amplifier, repeater, etc. However, the present optical fiber amplifier is not versatile, and is compelled to have different configurations for different purposes. This makes it possible to manufacture low-cost optical fiber amplifiers through mass production.

【0008】 (3) An optimal backup system in preparation for an emergency has not been found out.

【0009】 Accordingly, it is an object of the present invention to solve the aforementioned defects in the prior art, so as to provide an optimal backup system in preparation for an emergency, and to provide a versatile system for use in a variety of applications.

【0010】

【Means to solve the problems】 In order to attain the aforementioned objects, the excitation light source backup method for an optical fiber amplifier in accordance with the present invention includes: connecting optical coupling and decoupling directional couplers for coupling and decoupling an excitation light to the front and the rear of a rare-earth element doped optical fiber propagating a signal light; connecting, to each one end of the two optical directional couplers, semiconductor lasers for excitation so as to make the excitation light incident and propagated to the rare-earth element doped optical fiber, and providing a drive circuit for driving either one of the semiconductor lasers via a switch; connecting monitoring photodetector circuits to the other ends of the optical directional couplers; inputting outputs of the monitoring photodetector circuits to a comparator circuit and comparing the outputs with a reference voltage; and controlling the switch using the comparator circuit outputs, so as to drive either of the semiconductor lasers for excitation. Here, the monitoring photodetector circuits may detect a backward light, instead of directly

receiving a portion of the excitation light from the optical directional couplers. Also, a ring resonator may be used as optical directional coupler. Further, it is also possible to juxtapose two rare-earth element doped optical fibers, and the excitation light is equally divided into two, by use of an optical directional coupler for coupling and decoupling, constituted of an optical Y-branching circuit, so that each divided excitation light is propagated in each optical fiber.

【0011】

【 Functions 】 According to the above-mentioned configuration, either one of the semiconductor laser for excitation selected by the switch is driven, and when a monitoring signal reduction occurs in the monitoring photodetector circuit, the switch is shifted to the other side using the output of the comparator circuit, so as to drive the other semiconductor laser for excitation which has not been driven so far. Thus the backup can be achieved properly.

【0012】

【Embodiments】 Embodiments of the present invention will be described hereafter referring to the accompanied drawings.

【0013】 FIG. 1 shows a first embodiment of the present invention.

【0014】 In FIG. 1, an optical fiber 1 in which Er is doped as rare earth element is used. On both ends of the optical

fiber 1, optical fibers 14a, 14b having no rare-earth element doped are connected. A signal light (wavelength band 1.5 μm) is transmitted in these optical fibers 14a, 14b in the direction shown by arrows, from A1 to A2.

【0015】 Optical directional couplers 8a, 8b for excitation light coupling and decoupling are provided halfway the optical fibers 14a, 14b, through which the excitation light (wavelength band of 1. 48 μm, 0.98 μm or 0.8 μm) is propagated after coupling, and removed after decoupling. Each optical directional coupler 14a, 14b is structured as branching device having such a wavelength characteristic as passing the signal light as it is, and branching the excitation light selectively. Accordingly, the excitation light output from semiconductor lasers 3a, 3b for excitation (light sources having a wavelength band of 1.48 μm, 0.98 μm or 0.8 μm) is forwarded into Er-doped optical fiber 1 via optical directional coupler 8a. Also, the excitation light leaked to the output side can be separated by optical directional coupler 8b.

【0016】 A comparator circuit 6a (or 6b) compares an output voltage of a monitoring photodetector circuit 5a (or 5b) with a reference voltage 11, and outputs a digital output '1' or '0' according to the comparison result in view of the magnitude. Further, a comparator circuit 6c compares the outputs of comparator circuits 6a, 6b, and outputs a digital signal, to perform switching operation of a switch 7 so as to switch on the A side or the B side.

【0017】 A drive circuit 4 drives semiconductor lasers 3a, 3b for excitation. For example, first, by setting switch 7 on the A side, and semiconductor laser 3a for excitation is driven by drive circuit 4. While semiconductor laser 3a for excitation is operating normally, a portion of the excitation light is input into the monitoring photodetector circuit 5a, and a signal output is obtained from the output end of photodetector circuit 5a. Thus, an output of comparator circuit 6a is kept in a state '1'. Meanwhile, an output of comparator circuit 6b is kept in a state '0', since no signal is input to the input of the monitoring photodetector circuit 5b. To the output of comparator circuit 6c, a digital signal output for maintaining switch 7 on the A side is continued. In this condition, when an illumination output of semiconductor laser 3a for excitation is decreased, or stopped, caused by a performance deterioration, an unexpected trouble, etc., the output of the monitoring photodetector circuit 5a becomes smaller than a reference voltage 11, and the output of comparator circuit 6a turns to '0' state. As a result, the output of comparator circuit 6c also becomes '0' state, and accordingly, switch 7 is switched from the A side to the B side. This enables semiconductor laser 3b driven by drive circuit 4, and thus, the backup of semiconductor laser 3a for excitation is achieved.

【0018】 FIG. 2 shows a second embodiment of the invention.

【0019】 In this embodiment, the dispositions of the

monitoring photodetector circuits 5a, 5b are shifted, so as to detect backward lights of semiconductor lasers 3a, 3b for excitation.

【0020】 According to this configuration, since the output conditions of semiconductor lasers 3a, 3b can be monitored directly, switchover of the semiconductor lasers for excitation can be performed accurately. In addition, since semiconductor lasers 3a, 3b for excitation and photodetector circuits 5a, 5b can easily be structured and mounted in an integral form, a compact structure can be achieved.

【0021】 FIG. 3 shows a third embodiment of the invention.

【0022】 This embodiment has a structure constituted of optical ring resonators 10a, 10b, in place of the optical directional couplers for excitation light coupling and decoupling employed in the first embodiment of the invention.

【0023】 FIG. 4 shows a fourth embodiment of the invention.

【0024】 In this embodiment, a system includes two vertically juxtaposed configuration sets of the first embodiment. In the two optical fibers 1A, 1B each having the doped rare earth element, signals are transmitted in the directions shown by arrows A1 to A2, and B2 to B1, respectively, or in the reverse directions to the above, or in an identical direction. With this configuration bidirectional transmission can be performed between two points using two optical fibers 1A, 1B, and thus, signal

transmission with larger capacity and bandwidth can be achieved.

【0025】 In this configuration, optical directional couplers 9a, 9b for excitation light coupling and decoupling are coupled with optical Y-branching circuits 12a, 12b, so that excitation arises in both optical fibers 1A, 1B by a single semiconductor laser 3a or 3b. In this embodiment, the signal light propagation directions of A1 to A2, and B2 to B1, are shown as the opposite directions. However, an identical propagation direction may also be acceptable.

【0026】 The present invention is not limited to the embodiments described above. For example, a rare-earth element doped optical fiber having such an element as at least one of Nd, Pr, Sm, Tm, Yb, Ce, Ho, etc. may be used, instead of Er. Also, needless to say, the optical fiber may include at least one doped material among Al, Ge, Cr, etc., which will influence the gain characteristic. In place of the optical fiber types of optical directional coupler for optical coupling and decoupling of the excitation light, optical ring resonator, optical Y-branching circuit, etc., it may also be possible to use an optical waveguide type or a combined type of discrete parts (for example, combinations of discrete parts such as lens, optical interference film filter, and half mirror). The wavelength band of the signal light is selected depending on the types of the rare earth doped optical fiber

for use. For example, when using an optical fiber in which Nd or Pr is doped, a wavelength band of 1.3 μm is used.

【0027】 In FIGS. 1 - 4, optical fibers 14a, 14b disposed in front and rear of the rare-earth element doped optical fiber may be substituted by a waveguide when the optical directional coupler for excitation light coupling and decoupling, the optical ring resonator, etc. are structured of waveguide type.

【0028】

【Effects of the invention】 To summarize, the following effects are obtained according to the present invention.

【0029】 (1) The most appropriate backup system of the excitation light source can be provided in preparation for an emergency.

【0030】 (2) The system is of wide use and is applicable for a variety of applications for booster amplifier, pre-amplifier, repeater, etc., and accordingly, a remarkable cost reduction can be expected by mass production.

【0031】 (3) Backup of the excitation light source can be achieved with accuracy and sufficient responsibility in preparation for an emergency.

【0032】 (4) Using two rare earth doped optical fibers, bidirectional transmission or transmission in an identical direction can be achieved more economically, and high-speed and wideband signal transmission becomes possible.

【Brief description of the drawings】

【FIG. 1】 shows a first embodiment of the present invention.

【FIG. 2】 shows a second embodiment of the present invention.

【FIG. 3】 shows a third embodiment of the present invention.

【FIG. 4】 shows a fourth embodiment of the present invention.

【FIG. 5】 shows a conventional example.